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# Cooking Quality, Specific Gravity, and Reducing-Sugar Content of Early-Crop Potatoes[1]

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## CONTENTS



## INTRODUCTION

In the spring and summer months early-crop potatoes are much in demand to augment the supply of late-crop potatoes coming out of storage. Through this period the stored potatoes are not only diminishing in supply but are likely to be of doubtful market quality.

Potatoes of the early crop are usually dug before the tubers reach maturity, hence they differ in composition and cooking quality from those grown to maturity for winter storage. To be ready for shipping from January into the spring and summer months, early potatoes are grown in different areas and under climatic conditions that vary from those best suited for the winter storage crop. Because early potatoes are highly perishable, Rose (*12*) [3] recommends that they be picked up promptly after being dug, and protected from wind and heat injury during transportation from the field to the packing house. Further precautions during shipping should be taken to maintain qual-

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[3] Italic numbers in parentheses refer to Literature Cited, p. 22.

ity until potatoes reach the market. Of these, standard ventilation, initial icing, precooling, and refrigeration or protection by tarpaulins have been recommended for the various weather conditions encountered in the different parts of the country.

Cooking quality of late-crop potatoes is influenced by many production factors. Important among these are variety, temperature and other climatic conditions, soil types, fertilizer treatments, and maturity. Effects of conditions of growth are often interrelated and not easily distinguished.

Relatively little has been published about the cooking quality of early potatoes. The relation of factors such as color, dryness, mealiness, and flavor of early potatoes to variety and growing area has not been thoroughly investigated.

## PREVIOUS WORK

Several writers (*6*, *9*, *15*) have stated that immature potatoes may be low in mealiness. Willaman and West (*16*) confirmed the work of Langworthy (*9*) when they found early varieties of potatoes tended to be low in dry matter. Child and Willaman (*2*) later reported that higher amount of dry matter tended to be accompanied by better texture.

Many workers have reported the close relationship of maturity in late-crop potatoes to general cooking quality. Gilmore (*5*) states that cooking quality is influenced by degree of ripeness. Findlay (*4*) has agreed that the quality of potatoes is not at its best unless tubers have reached full maturity. M'Intosh(*10*) reports that mature tubers are invariably of better quality than immature. Recently, Kunkel, Schaal, and Binkley (*8*) have taken the opposite point of view—that cooking quality as measured by specific gravity improves very little with maturity and possibly decrea ses. Their results, however were reported from tests made on onevariety, the tubers of which, measured in the low range for specific gravity (1.061–1.075).

Specific gravity has been studied by numerous investigators in recent years as a method for determining dry-matter content of potatoes and its relationship to cooking quality. Akeley and Stevenson (*1*) have reported that relatively large differences in density of tubers of the same variety occurred even when they were grown in the same field. Still greater differences were found when the same variety was grown in different locations. Smith and Nash (*14*) state that to standardize procedures and insure selection of representative tubers for small cooking samples they obtained the average specific gravity of the tubers from each treatment and then selected a sample from tubers having the average specific gravity of that lot. Kelly and Smith (*7*) also proposed selection of samples by the specific-gravity method to obtain a more accurate evaluation of the effect of certain treatments on texture.

## PURPOSE AND PLAN OF EXPERIMENT

A laboratory study was carried out in May and June 1949 to obtain data on the suitability of early potatoes for boiling, mashing, baking, french-frying, and use in salad. In conjunction with french-frying

tests chemical analyses of raw stock for moisture and reducing sugar were made. Specific-gravity measurements were used as a means of selecting cooking samples from all lots.

The experiment included three replications for each of six lots of potatoes with each cooking method. Palatability scores of seven trained judges were compared by analysis of variance. Correlation coefficients were determined for certain individual quality factors and/or specific gravity, dry matter, and reducing sugar.

## EXPERIMENTAL PROCEDURE

Four varieties of early potatoes were purchased in 200-pound lots from commercial growers during the last 2 weeks in May 1949. Triumph and Sebago potatoes were obtained from two sources, Alabama and South Carolina; Irish Cobbler potatoes were obtained from North Carolina, and White Rose potatoes were shipped from California. Potatoes were held at 60° F. until the laboratory cooking tests were completed.

Potatoes from the South Atlantic areas were shipped by express arriving at the laboratory about 3 days after being dug. White Rose potatoes from Kern County, Calif., were shipped under refrigeration at 50° to 55° F. The exact conditions under which all samples of potatoes were dug and held prior to shipping were not known

The skins of potatoes of all samples were feathered to some extent. Triumph potatoes from South Carolina had moderately thin skin and showed slight feathering. In addition, the tubers of this sample had a slight amount of scab and many cuts. A moderate amount of feathering had occurred in the Triumph variety from Alabama, the Sebago from Alabama and South Carolina, and the White Rose variety from California. Irish Cobbler potatoes from North Carolina showed evidence of skinning and slight browning. Some green tubers were also present in the Irish Cobbler sample.

There was considerable difference in size of individual tubers between varieties. None of the sample lots of potatoes when received were free from slight amounts of rot and mold.

### Selection of Samples

The entire 200-pound lot of potatoes of each variety and location was examined as soon as received. Cooking samples were selected for freedom from decay, for uniformity of size, and for specific gravity. Specific gravity determinations were made on a 50-tuber sample of potatoes selected at random. Tubers were washed, dried, and immersed in salt solutions of known specific gravity (1.05, 1.06, 1.07, 1.08, 1.09) as shown in figure 1, according to the method described by Clark, Lombard, and Whiteman (*3*). Tubers were put into the solution of lowest density first (in this experiment 1.05). If they sank they were transferred successively to solutions of higher density until the solution was reached in which the tubers just floated. The specific gravity of a tuber was considered the same as that of the solution in which it floated.

From the combined record of the specific gravity of the tubers in the 50-tuber samples the modal specific-gravity class for each particular


FIGURE 1.—Determining specific gravity of potato tubers.

lot was determined. Additional tubers were measured for specific gravity to obtain a sufficient number from the modal specific-gravity class of each lot for three replications, for all methods of cooking as well as for chemical analyses. Tubers selected for specific gravity were measured for thickness (smallest diameter) by means of a suitable caliper (fig. 2). Six-tuber cooking samples were obtained from modal specific-gravity classes, with no more than 0.2-cm. variation in thickness among tubers.

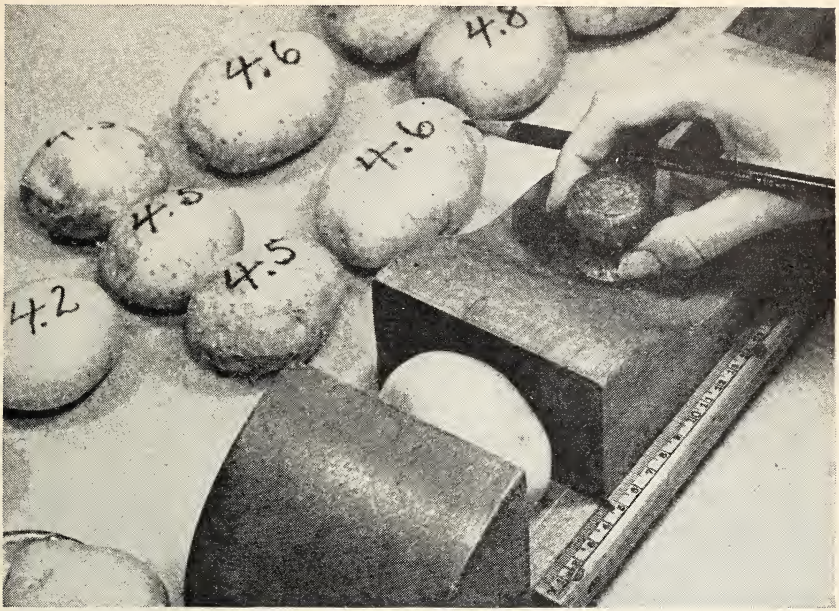


FIGURE 2.—Measuring thickness of potato tubers as a means of selecting uniformly sized cooking samples.

## Cooking Methods

Six selected tubers comprising each cooking sample were washed, dried, and weighed, before preparing for cooking. One tuber of each sample was threaded with an iron-constantan thermocouple with the thermocouple junction in the center of the tuber to measure the internal temperature as a control for doneness. This tuber was not used for palatability judging.

Potatoes for boiling and mashing were peeled in an abrasive mechanical peeler for 20 seconds, then hand trimmed and eyed, dried and weighed. The pared tubers were covered with damp cheesecloth until put on to cook. A thermocouple was placed in each cooking pot to record water temperature. Cooking was done on identical electrical units of controlled wattage in uniform enameledware kettles of 3-quart capacity. The pared samples varying in weight from 533 to 972 gm. were placed in a minimum amount of boiling distilled water (800 to 900 ml.) and covered with a lid. Internal temperatures of potatoes and water temperatures for all samples cooked were recorded on an electronic recording potentiometer.

Boiled potatoes were cooked to an internal temperature of 96° C. (205° F.). Cooked potatoes were drained immediately in enameledware colanders lined with cheesecloth, samples were weighed, and each tuber cut in lengthwise quarters; half were used for scoring of boiled samples and half were reserved for mashing. The potatoes for mashing were put through a ricer and stirred 30 strokes with a table fork. No seasonings were added.

Seven quarters of each boiled sample—one for each judge—were

placed for scoring visual characteristics in a white porcelain dish in a specially constructed viewing cabinet equipped with artificial daylight lamps. Six coded cooked samples were observed by the judges at one time. Immediately following the visual scoring the potatoes were tasted. Portions of the mashed potatoes for judging were measured with a No. 30 scoop into heated white porcelain dishes and coded for scoring by the judging panel.

Potatoes for baking were weighed and trimmed of defects when necessary. The six-tuber baking sample varied in weight from 826 to 1,401 gm. Baking was done in a preheated Despatch electric oven, with the thermostat set at 218° C. (425° F.). Oven temperatures were recorded by two thermocouples fastened to the rack in the center of the oven. Potatoes were baked until the internal temperature reached 98° C. (208° F.). Baked tubers were removed from the oven, cut in half lengthwise from stem to bud end, and placed on coded trays for judging.

Samples of potatoes for salad were cooked with and without skins. Potatoes for the pared sample were put through a mechanical potato peeler, boiled according to standardized procedure previously described, drained, and cooled for 2 hours at room temperature. The unpared sample was cooked by the same method and cooled in a pan over iced water for 2 hours. Potatoes cooked in skins cooled more slowly than cooked pared potatoes, hence it was necessary to use ice to speed cooling of unpared samples. The thermocouple was retained in one tuber of each sample to record the internal temperature and make possible control of rate of cooling, so that both pared and unpared samples cooled to room temperature (approximately 80° F.) in 2 hours. Skins were removed from cooled, unpared samples. Potatoes from both pared and unpared cooking lots were cut in ½-inch cubes, tossed 30 strokes with a large blending fork, and sampled for judging.

Tubers for french frying were pared by hand, and each tuber was cut in half, from stem to bud end. One-half of each tuber was cut into strips with a 3/8-inch cutter for frying and the other half sampled for chemical analyses (fig. 3). Four cooking samples were prepared daily. To hold before cooking, cut strips were covered with distilled water for 10 minutes, drained for 1 minute in an enameledware colander, and wiped dry with cheesecloth.

Two identical frying kettles of 4-quart capacity were used; one for the first stage cooking, the other for second stage, or final cooking. Both kettles were equipped with wire baskets and also with thermometers for recording the fat temperatures (fig. 4). Raw potato strips were fried in peanut oil; a 3 to 1 proportion of oil to raw potato was used. Cooking oil was strained after each use and was re-used 12 times, more being added as needed to replace that lost in cooking. For first stage 1,050 gm. of peanut oil in kettle 1 was heated to 190° C. (375° F.); 350 gm. of potato strips were added and cooked 2½ minutes. Partly cooked strips were drained for 1 minute and put into kettle 2 containing 1,050 gm. of oil which had been heated to 205° C. (400° F.) and were fried 5 minutes. Following a 1-minute draining period, excess oil was blotted from strips with paper towels and a representative sample of six french-fried strips was selected for each judge.

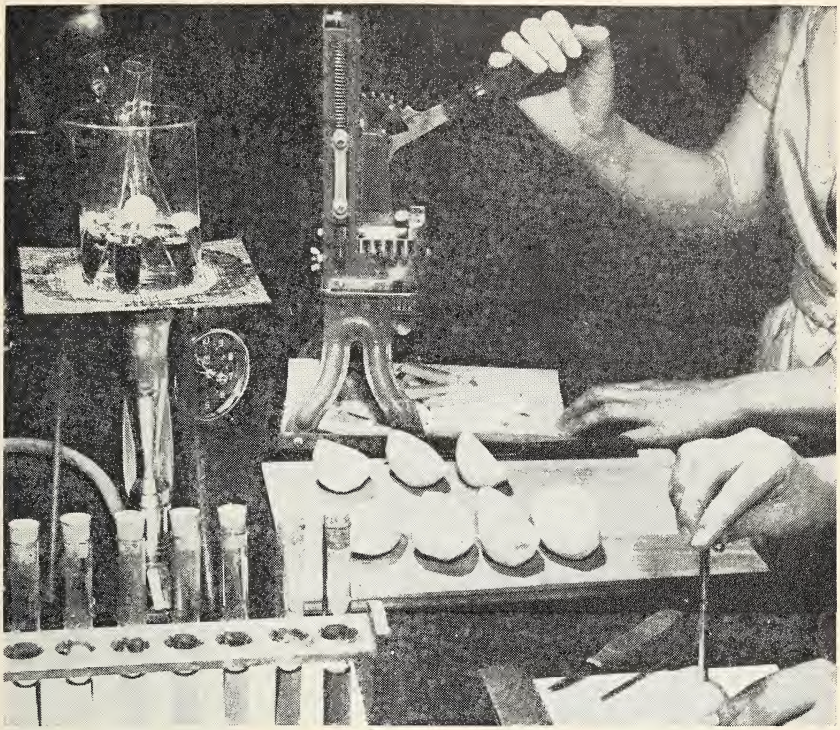

FIGURE 3.—Cutting potato tubers for french frying and sampling for determinations of reducing sugar.

## Analysis for Reducing Sugars and Dry Matter

A rapid test employing picric acid as a reagent was used to estimate the reducing sugar content of tubers. Each tuber was sampled by the procedure described by Peacock and Brunstetter (*11*). A cork borer with a 3/16-inch inside diameter was used to cut a cylinder from the tuber about midway between the stem and bud ends. After the outer corky tissue was removed, a 1-inch length of the cylinder was cut off and dropped into a test tube containing 3 ml. of 0.2-percent picric acid solution. One-half milliliter of 5-percent sodium hydroxide and five drops of 50-percent acetone were added to each tube, the contents mixed, and the tubes placed in a boiling water bath slightly deeper than the level of the solutions in the tubes. After 12 minutes the tubes were removed and the content made up to 10-ml. volume in the previously calibrated test tubes. The reagents and heating procedure used were the same as those described by Ross and coworkers (*13*). The sugar concentration was estimated by comparing the color with a set of standards made in the same manner from pure dextrose solutions ranging in concentration from 0.125 to 3.0 mg. of dextrose per tube. At least one cylinder was taken from each of the six tubers used in each cooking test.

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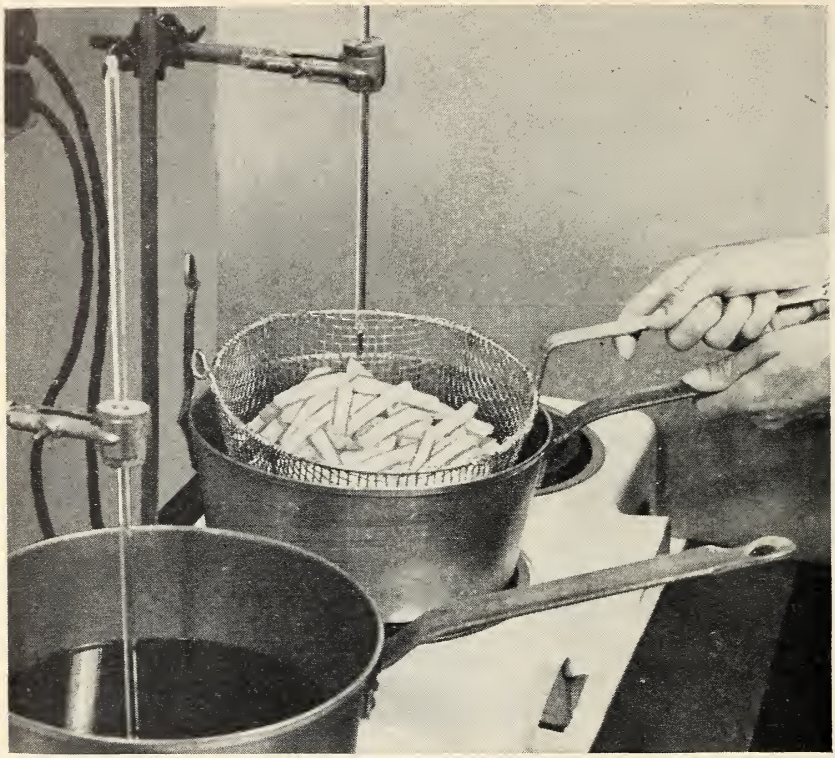

FIGURE 4.—Lowering partly cooked potato strips into hot fat for final frying.

Dry-matter determinations were made by grinding one-fourth of each of the six tubers in a food chopper and drying a portion of the composite sample in a convection oven for 24 hours at 70° C. The samples were transferred to a vacuum oven and dried overnight at a temperature of 70° C. and in a vacuum of approximately 28 inches of mercury.

## METHODS FOR PALATABILITY TESTING

Cooking quality of early potatoes for use boiled, mashed, baked, french fried, and in salad was determined by evaluation of the cooked product. A judging panel, previously trained in judging quality of storage potatoes, also scored these samples from the early crop. Standards for quality of cooked potatoes used as a basis for palatability judging included many of the same characteristics long recognized as important and reported in previous work (*2*, *3*, *15*, *17*). Creamy white color; dry mealy texture; degree of sloughing or disintegration when boiled; and mild, natural potato flavor are predetermined standards which were applied to boiled, mashed, baked, and salad potatoes. In judging french-fried potatoes, standards included uniform light golden-brown color; crisp, tender crust; dry, mealy interior; and natural, desirable flavor.

M'Intosh (*10*) has brought out the fact that new and mature potatoes are often judged by different standards. An important factor to bear in mind when interpreting results reported in this circular is that standards for quality, judging record sheets, and judging panel were the same as used in a study of late potatoes carried on concurrently in this Department.

Boiled potatoes were scored by visual evaluation of the appearance characteristics, color, and sloughing. Dryness, mealiness, and flavor were scored after judges tasted the samples. (See judging record, p. 10.) Except for the sloughing characteristic, mashed and baked potatoes were judged for the same qualities as boiled potatoes. Salad potatoes were scored for form retention which included sloughing plus loss of shape when cut pieces were tossed together. Scoring french-fried potatoes required of panel members both visual and tasting techniques especially adapted to the french-fried product. (See judging record, p. 11.) For each cooking method a 3 to 1 judging scale, 3 representing the highest score, was established with adequate descriptive terms for each point on the scale. Descriptive terms were set up with the aid and approval of panel members and thus represented a standard each one could accept and easily remember. This was an important feature in training the individual members of the panel to keep in mind the same measurements throughout the study.

Judging was done by seven judges independently in a room separate from that in which the samples were prepared. The room was adequately ventilated and lighted with artificial daylight lamps to further standardize conditions of judging (fig. 5). All details of judging were developed from a quantitative objective standpoint and the influence of individual preferences was carefully avoided.

FIGURE 5.—A palatability panel independently judging cooking quality of baked potatoes.

JUDGING RECORD FOR BOILED POTATOES

Name of judge_____ Date_____

| Sample number | 1 | | 2 | | 3 | | 4 | | 5 | | 6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Quality factors* | Score | | Score | | Score | | Score | | Score | | Score | |
| Color: | | | | | | | | | | | | |
| 3—Creamy white | | | | | | | | | | | | |
| 2—Slightly yellow or gray | | | | | | | | | | | | |
| 1—Yellow or gray | | | | | | | | | | | | |
| (Check yellow or gray) | Y | G | Y | G | Y | G | Y | G | Y | G | Y | G |
| Sloughing: | | | | | | | | | | | | |
| 3—Little or no sloughing | | | | | | | | | | | | |
| 2—Moderate sloughing or scaling of outside layer | | | | | | | | | | | | |
| 1—Intense sloughing or disintegration | | | | | | | | | | | | |
| Dryness: | | | | | | | | | | | | |
| 3—Dry | | | | | | | | | | | | |
| 2—Slightly moist | | | | | | | | | | | | |
| 1—Watery or soggy | | | | | | | | | | | | |
| Mealiness: | | | | | | | | | | | | |
| 3—Mealy | | | | | | | | | | | | |
| 2—Moderately mealy | | | | | | | | | | | | |
| 1—Waxy, cohesive | | | | | | | | | | | | |
| Flavor: | | | | | | | | | | | | |
| 3—Natural, desirable | | | | | | | | | | | | |
| 2—Some off-flavor, slightly undesirable | | | | | | | | | | | | |
| 1—Strong off-flavor, undesirable | | | | | | | | | | | | |
| Check for presence of flavors: | | | | | | | | | | | | |
| Natural | | | | | | | | | | | | |
| Sweet | | | | | | | | | | | | |
| Earthy | | | | | | | | | | | | |
| Bitter | | | | | | | | | | | | |
| Nutty | | | | | | | | | | | | |
| Astringent | | | | | | | | | | | | |
| Stale | | | | | | | | | | | | |
| Watery | | | | | | | | | | | | |
| Metallic | | | | | | | | | | | | |

JUDGING RECORD FOR FRENCH-FRIED POTATOES

Name of judge_____ Date_____

| Sample number | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| *Quality factors* | Score | Score | Score | Score |
| Color (outside):<br>3—Golden, uniform_____<br>2—Medium dark or too light or not uniform_____<br>1—Dark, much variability____ | | | | |
| Crispness:<br>3—Crisp, tender_____<br>2—Slightly leathery, limp, or tough_____<br>1—Leathery, limp, or tough___ | | | | |
| Dryness:<br>3—Dry, mealy_____<br>2—Slightly soggy_____<br>1—Soggy_____ | | | | |
| Flavor:<br>3—Natural, desirable_____<br>2—Some off-flavor, slightly undesirable_____<br>1—Strong off-flavor, undesirable_____ | | | | |
| Check for presence of flavors: | | | | |
| Natural_____ | | | | |
| Sweet_____ | | | | |
| Earthy_____ | | | | |
| Bitter_____ | | | | |
| Nutty_____ | | | | |
| Astringent_____ | | | | |
| Stale_____ | | | | |
| Watery_____ | | | | |
| Metallic_____ | | | | |
| Burned_____ | | | | |
| Scorched_____ | | | | |
| Acrid _____ | | | | |

## RESULTS

The distribution in the different specific-gravity classes of all lots of potatoes is shown in table 1. Some samples exhibit a tendency to a wider scattering in various specific-gravity classes than others and thus have a relatively smaller number of tubers falling in the modal specific-gravity class. A study of the distribution of specific-gravity values shows that the number of tubers from each sample lot falling in the modal specific-gravity class ranged from 137 out of 280 (49 percent) to 224 out of 290 (77 percent). This appears not to be a varietal difference as shown by samples of Sebago from the two locations. Modal specific-gravity classes of the six sample lots of

early potatoes used in this study ranged from 1.06 to 1.08. Data in table 1 show variation in specific gravity for Triumph and Sebago varieties from different locations. Both South Carolina samples had higher specific-gravity values than the corresponding Alabama samples.

Palatability scores from a trained panel and data from chemical analyses have been used in determining and analyzing the results of this study. Boiling is the only method of cooking used in which sloughing or scaling of the cortical layer was a pertinent factor. As shown by judges' scores in table 2, sloughing was slight and differences between samples were nonsignificant.

TABLE 1.—*Specific gravity of six samples of early potatoes*

| Sample (variety and location) | Total number of tubers tested | Number of tubers in each specific-gravity class | | | | | Modal specific-gravity class |
|---|---|---|---|---|---|---|---|
| | | 1. 05 | 1. 06 | 1. 07 | 1. 08 | 1. 09 | |
| Irish Cobbler, N. C | 241 | ------ | 6 | 177 | 55 | 3 | 1. 07 |
| Sebago, Ala | 228 | ------ | 30 | 144 | 53 | 1 | 1. 07 |
| Sebago, S. C | 280 | 4 | 44 | 75 | 137 | 20 | 1. 08 |
| Triumph, Ala | 290 | 9 | 224 | 51 | 6 | ------ | 1. 06 |
| Triumph, S. C | 245 | ------ | 25 | 170 | 46 | 4 | 1. 07 |
| White Rose, Calif | 223 | 45 | 145 | 29 | 4 | ------ | 1. 06 |

Scores for the quality factor, dryness, showed a varied amount of deviation from the highest possible score of 3; those for baked potatoes showed the greatest deviation as they were the lowest scores. Potatoes cooked by boiling scored only slightly higher in dryness than baked potatoes; in boiled potatoes no significant differences in scores for dryness were found among samples. In mashed potatoes, however, sample differences in scores for dryness were significant at the 1-percent level indicating that some samples gave distinctly drier mashed potatoes than others. The Sebago and Irish Cobbler samples scored highest with mean scores of 2.6, 2.7, and 2.5 showing a relatively small deviation from the highest possible score of 3.

Scores for mealiness showed no significant difference between samples when potatoes were baked and boiled. Interpretation of mealiness scores showed that the potatoes were from "slightly" to "moderately" mealy. Sample differences were found in mealiness of mashed potatoes at the 5-percent level of significance. Sebago and Irish Cobbler samples scored highest in mealiness.

Considerable variation was found in the color of the cooked early potatoes. Analysis of data given in table 2 indicates that color of cooked potatoes differed significantly among samples. Color of potatoes cooked by boiling and baking differed significantly at the 1-percent level, whereas color of mashed samples showed significant differences at the 5-percent level. It has been observed in the laboratory that ricing and stirring to simulate "mashing" lightens the

TABLE 2.—*Means of judges' scores for palatability of early potatoes, boiled, mashed, and baked*

| Sample (variety and location) | Modal specific-gravity class | Cooking method | Palatability factors [1] | | | | |
|---|---|---|---|---|---|---|---|
| | | | Sloughing | Color | Dryness | Mealiness | Flavor |
| Irish Cobbler, N. C. | 1.07 | Boiled | 2.5 | 1.7 | 2.2 | 2.0 | 2.1 |
| | | Mashed | | 2.1 | 2.5 | 2.3 | 2.2 |
| | | Baked | | 1.8 | 1.9 | 2.0 | 2.0 |
| Sebago, Ala. | 1.07 | Boiled | 2.4 | 2.1 | 2.5 | 2.3 | 2.8 |
| | | Mashed | | 2.5 | 2.6 | 2.5 | 2.6 |
| | | Baked | | 2.9 | 1.8 | 2.2 | 2.6 |
| Sebago, S. C. | 1.08 | Boiled | 2.4 | 1.9 | 2.3 | 2.2 | 2.5 |
| | | Mashed | | 2.0 | 2.7 | 2.4 | 2.5 |
| | | Baked | | 2.6 | 1.7 | 2.1 | 2.5 |
| Triumph, Ala. | 1.06 | Boiled | 2.6 | 2.6 | 2.2 | 2.0 | 2.4 |
| | | Mashed | | 2.8 | 2.1 | 2.1 | 2.2 |
| | | Baked | | 2.1 | 1.7 | 2.1 | 2.3 |
| Triumph, S. C. | 1.07 | Boiled | 2.3 | 2.6 | 2.1 | 2.1 | 2.3 |
| | | Mashed | | 2.8 | 2.1 | 2.1 | 2.2 |
| | | Baked | | 2.3 | 2.1 | 2.2 | 2.4 |
| White Rose, Calif. | 1.06 | Boiled | 2.4 | 1.8 | 2.2 | 2.1 | 2.0 |
| | | Mashed | | 2.1 | 1.8 | 2.0 | 2.0 |
| | | Baked | | 2.1 | 1.9 | 1.8 | 2.1 |

[1] Mean scores of 7 judges from 3 replications; a score of 3 represents the highest score, 1 the lowest.

color, thus reducing the amount of variation among samples. The mashed product did not always give higher color scores than boiled and baked, although in most cases this was true. When potatoes were boiled and mashed, Triumph variety from both locations scored higher for color than did the other samples.

Cooked early potatoes were found to differ significantly in flavor among samples. Variation was of greater significance (1-percent level) in baked potatoes than in those that were boiled and mashed (5-percent level). As shown in table 2 the sample of Sebago grown in Alabama scored highest of all samples for flavor when cooked by all three methods.

Early potatoes cooked and prepared as for salad were rated lower on the grading scale in all quality factors than those prepared as boiled, baked, or mashed. Scores in table 3 indicate that preparing these potatoes for salad gave a product less mealy, more moist and soggy, more yellow in color, with somewhat less desirable flavor than cooking them by other methods. Sample differences were not significant except for color of unpared tubers, in which there was significance at the 1-percent level. Comparison of tubers cooked pared and unpared showed a significant difference for color at the 1-percent level and for flavor at the 5-percent level. In both instances, the scores for pared tubers were higher than for unpared. Differences were not significant for form retention, dryness, and mealiness although, in general, the values for the pared tubers were equal to or higher than those for unpared tubers.

Means of judges' scores for palatability of french-fried potatoes show that none of the early potatoes tested were highly desirable for french frying (table 4). Differences among samples were found in color, flavor, and dryness at the 1-percent level of significance. Sebago and Irish Cobbler samples scored slightly higher for color, crispness, and flavor than the other varieties. All of the samples made french-fried potatoes browner in color, less crisp and dry, and with more scorched taste than the accepted standard for this product. Scores for crispness of the outer crust of french-fried strips show variation similar to that of other factors studied. Color scores were shown to decrease as the values for reducing sugar increased. The Alabama sample of Sebago scored highest for color and contained the lowest amount of reducing sugar, 0.064 percent (fresh weight basis). On the other hand, the White Rose sample from California scored 1 (lowest) in color and was found to contain 0.505 percent reducing sugars. The high reducing-sugar content of White Rose sample can be attributed to refrigeration of these potatoes while in transit. Refrigeration is known to further accumulation of reducing sugars within the tubers. Differences in dry matter show some relationship to judges' scores for dryness as well as to the specific gravity of the tubers.

Considerable difference in reducing-sugar content was found within the six-tuber sample of each lot tested (table 5). Variation in color of french-fried strips cut from the six tubers and cooked as one sample was noted. This color variation was more evident during the early part of the cooking process when some strips browned more quickly than others.

TABLE 3.—*Means of judges' scores for palatability of early potatoes prepared for salad*

| Sample (variety and location) | Modal specific-gravity class | Preparation for cooking | Palatability factors [1] | | | | |
|---|---|---|---|---|---|---|---|
| | | | Form retention | Color | Dryness | Mealiness | Flavor |
| Irish Cobbler, N. C | 1.07 | Pared | 2.4 | 1.7 | 2.0 | 1.8 | 2.2 |
| | | Unpared | 2.6 | 1.5 | 2.0 | 1.6 | 1.9 |
| Sebago, Ala | 1.07 | Pared | 2.0 | 2.2 | 1.9 | 1.6 | 2.3 |
| | | Unpared | 1.9 | 2.2 | 1.8 | 1.9 | 2.0 |
| Sebago, S. C | 1.08 | Pared | 2.2 | 2.1 | 1.9 | 1.4 | 2.4 |
| | | Unpared | 2.2 | 1.8 | 1.7 | 1.3 | 2.1 |
| Triumph, Ala | 1.06 | Pared | 2.6 | 2.2 | 1.9 | 1.5 | 2.2 |
| | | Unpared | 2.5 | 1.6 | 1.8 | 1.3 | 2.1 |
| Triumph, S. C | 1.07 | Pared | 2.4 | 2.4 | 1.7 | 1.7 | 2.3 |
| | | Unpared | 2.1 | 1.9 | 1.6 | 1.6 | 2.3 |
| White Rose, Calif | 1.06 | Pared | 2.4 | 2.1 | 1.7 | 1.8 | 2.1 |
| | | Unpared | 2.2 | 2.1 | 1.7 | 1.8 | 1.8 |

[1] Mean scores of 7 judges from 3 replications; a score of 3 represents the highest score, 1 the lowest.

TABLE 4.—*Dry matter, reducing-sugar content, and palatability of early potatoes cooked by french frying*

| Sample (variety and location) | Modal specific-gravity class | Dry matter | Reducing sugar | Palatability factors [1] | | | |
|---|---|---|---|---|---|---|---|
| | | | | Color | Crispness | Dryness | Flavor |
| | | *Percent* [2] | *Percent* [2] | | | | |
| Irish Cobbler, N. C | 1. 07 | 20. 5 | 0. 093 | 2. 0 | 2. 0 | 1. 7 | 2. 3 |
| Sebago, Ala | 1. 07 | 18. 5 | . 064 | 2. 2 | 1. 8 | 2. 0 | 2. 2 |
| Sebago, S. C | 1. 08 | 20. 8 | . 134 | 1. 9 | 2. 0 | 1. 7 | 2. 0 |
| Triumph, Ala | 1. 06 | 16. 8 | . 154 | 1. 8 | 1. 5 | 1. 4 | 1. 7 |
| Triumph, S. C | 1. 07 | 19. 3 | . 161 | 1. 7 | 1. 6 | 1. 7 | 1. 9 |
| White Rose, Calif | 1. 06 | 17. 0 | . 505 | 1. 0 | 1. 2 | 1. 4 | 1. 1 |

[1] Mean scores of 7 judges from 3 replications; a score of 3 represents the highest score, 1 the lowest.
[2] Fresh-weight basis.

TABLE 5.—*Range in reducing-sugar content within six-tuber samples of early potatoes*

| Sample (variety and location) | Percent [1] reducing sugar | | |
|---|---|---|---|
| | Replicate 1 | Replicate 2 | Replicate 3 |
| Irish Cobbler, N. C | 0. 050–0. 200 | 0. 075–0. 150 | 0. 075–0. 100 |
| Sebago, Ala | . 050– . 075 | . 047– . 075 | . 047– . 075 |
| Sebago, S. C | . 100– . 200 | . 087– . 225 | . 100– . 175 |
| Triumph, Ala | . 125– . 175 | . 100– . 200 | . 100– . 225 |
| Triumph, S. C | . 100– . 225 | . 150– . 250 | . 125– . 200 |
| White Rose, Calif | . 400– . 500 | . 350– . 600 | . 450– . 650 |

[1] Fresh-weight basis.

In considering the results of the tests here described it must be remembered that to increase the reliability of the data in this study all potatoes were judged by the same standards. That is, a dry, mealy potato white in color was set as the standard for salad potatoes, as well as for those boiled, mashed, and baked. This procedure is in contrast to reports in the literature that different standards have been set up to score potatoes used in salad. Potatoes suitable for salad may be moderately dry and have a medium degree of mealiness. Neither very dry nor very soggy potatoes make the best salad. Therefore a medium score of 2 for dryness and mealiness indicates good quality for salad use. Both color and flavor will be modified by salad dressing and other added ingredients in actual use of potatoes in salad. Color and flavor scores, although lower than would be considered desirable for boiled, mashed, or baked potatoes, do not indicate low quality in the end product of potato salad.

Differences among samples in the retention of form of cut pieces were not significant. All samples showed some breakdown due to tossing to simulate blending for salad. In actual use, salad dressing would probably decrease breaking of potato cubes during the mixing process.

As a means of identifying the off-flavors occurring in cooked potatoes, a list of descriptive terms was made a part of the judging record for all cooking methods. Potato samples were cooked and prepared for judging without salt or other seasoning to mask or otherwise counteract the off-flavors present. Judges checked for the presence of each flavor in every sample. For some samples a number of off-flavors were checked, for others only one. Frequency of use of each flavor term is given in table 6. The terms "sweet" and "burned" were applied the greatest number of times to the White Rose sample which was found to contain the highest percent of reducing sugar. Natural flavor predominated in all samples other than White Rose although earthy and bitter flavors were frequently detected.

Coefficients of correlation were computed by using mean values throughout; that is, the coefficients refer to correlations among the six sample lots (four varieties, two of which were from two growing areas). Correlation of specific gravity with a chemical analysis for dry matter shows a positive relationship of +0.891, which is signifi-

TABLE 6.—*Frequency of use of descriptive terms applied to flavor of early potatoes judged as boiled, mashed, baked, french-fried, and salad potatoes* [1]

| Term | Irish Cobbler (N. C.) | Sebago (Ala.) | Sebago (S. C.) | Triumph (Ala.) | Triumph (S. C.) | White Rose (Calif.) |
|---|---|---|---|---|---|---|
| Natural | 55 | 47 | 52 | 50 | 61 | 30 |
| Sweet | 17 | 8 | 15 | 15 | 20 | 45 |
| Earthy | 34 | 26 | 38 | 27 | 24 | 32 |
| Bitter | 39 | 12 | 15 | 27 | 26 | 26 |
| Nutty | 5 | 6 | 4 | 4 | 5 | 8 |
| Astringent | 1 | 3 | 4 | 9 | 1 | 6 |
| Stale | 12 | 7 | 8 | 8 | 4 | 6 |
| Watery | 4 | 3 | 5 | 7 | 3 | 8 |
| Metallic | 3 | 3 | | 5 | | 5 |
| Burned [2] | 1 | 5 | 5 | 5 | 5 | 16 |
| Scorched [2] | 9 | 8 | 7 | 11 | 9 | 6 |
| Acrid [2] | 3 | 1 | 4 | 3 | 3 | 1 |

[1] From a total of 105 judgments.
[2] Terms "burned," "scorched," "acrid," apply only to french-fried potatoes.

cant at the 5-percent level. This means that 79 percent of the variation in dry matter among sample lots was associated with specific gravity. Reducing-sugar content was negatively correlated with specific gravity (—0.560) and also with dry matter (—0.555); neither correlation is significant.

Table 7 shows correlations between (1) chemical analyses and palatability factors and (2) palatability factors themselves. Not all correlations are significant statistically but have been included because of the suggestive trends. For example, the preponderance of negative correlations between reducing sugar and the other quality factors for french-fried, boiled, mashed, and baked potatoes indicates a general lowering of desirable qualities possibly traceable to high reducing sugar content.

Table 7 shows significant negative correlations of color, flavor, and crispness scores of french-fried potatoes with reducing-sugar content of raw sample. In these instances, 96 percent of the variation in color, 86 percent of the variation in flavor, and 70 percent of the variation in crispness among samples were associated with the variation in the amount of reducing sugar. Additional significant relationships were indicated by the data. Crispness of the french-fried product was positively correlated with specific gravity and dry matter of raw samples as well as with the palatability characteristics, color and flavor. In both boiled and mashed potatoes mealiness was positively correlated with dryness; and mealiness was negatively correlated with reducing sugar in baked and mashed samples.

As the reducing-sugar content of potatoes increased, palatability scores for color, flavor, and crispness of french-fried potatoes decreased. With increase in reducing-sugar content the color of french-fried potatoes became darker and their flavor became more scorched or burned. A low score for flavor of both french-fried and mashed potatoes was accompanied by a low score for mealiness.

TABLE 7.—*Coefficients of correlation between specific gravity, reducing sugar, dry matter, and palatability factors of cooked early potatoes*

| Correlation factors | Method of preparation | | | | | |
|---|---|---|---|---|---|---|
| | French-fried | Boiled | Mashed | Baked | Salad (pared) | Salad (unpared) |
| Specific gravity versus: | | | | | | |
| Color | +0.559 | −0.301 | −0.359 | +0.478 | −0.177 | −0.032 |
| Flavor | +.667 | +.491 | +.623 | +.398 | +.933** | +.309 |
| Mealiness | | +.461 | +.689 | +.387 | −.486 | −.218 |
| Dryness | +.678 | +.238 | +.805 | −.033 | +.366 | −.175 |
| Sloughing | | −.561 | | | | |
| Form retention | | | | | −.594 | −.279 |
| Crispness | +.811* | | | | | |
| Reducing sugar versus: | | | | | | |
| Color | −.982** | −.224 | −.295 | −.239 | +.127 | +.308 |
| Flavor | −.929** | −.699 | −.718 | −.414 | −.747 | −.397 |
| Mealiness | | −.161 | −.815* | −.846* | +.371 | +.359 |
| Dryness | −.688 | −.326 | −.760 | +.084 | −.613 | −.338 |
| Sloughing | | +.014 | | | | |
| Form retention | | | | | +.277 | −.018 |
| Crispness | −.836* | | | | | |
| Dry matter versus: | | | | | | |
| Color | +.528 | −.452 | −.411 | +.069 | −.474 | −.301 |
| Flavor | +.732 | +.171 | +.347 | −.010 | +.764 | +.143 |
| Mealiness | | +.084 | +.546 | +.239 | +.170 | −.166 |
| Dryness | +.589 | +.010 | +.745 | +.185 | +.479 | +.150 |
| Sloughing | | −.448 | | | | |
| Form retention | | | | | +.383 | +.050 |
| Crispness | +.876* | | | | | |

See footnotes at end of table.

TABLE 7.—*Coefficients of correlation between specific gravity, reducing sugar, dry matter, and palatability factors of cooked early potatoes*—Continued

| Correlation factors | Method of preparation | | | | | |
|---|---|---|---|---|---|---|
| | French-fried | Boiled | Mashed | Baked | Salad (pared) | Salad (unpared) |
| Color versus: | | | | | | |
| Flavor | +.939** | +.318 | +.012 | +.880* | +.026 | −.456 |
| Mealiness | | −.120 | −.096 | +.487 | −.084 | +.748 |
| Dryness | +.761 | −.245 | −.355 | −.262 | −.777 | −.435 |
| Sloughing | | +.090 | | | | |
| Form retention | | | | | +.009 | −.930** |
| Crispness | +.847* | | | | | |
| Flavor versus: | | | | | | |
| Mealiness | | +.755 | +.945** | +.726 | −.620 | −.515 |
| Dryness | +.838* | +.715 | +.820* | −.225 | +.344 | −.623 |
| Sloughing | | −.194 | | | | |
| Form retention | | | | | −.504 | −.109 |
| Crispness | +.928** | | | | | |
| Mealiness versus: | | | | | | |
| Dryness | | +.816* | +.938** | +.092 | −.299 | +.076 |
| Sloughing | | −.440 | | | | |
| Form retention | | | | | +.183 | +.540 |
| Dryness versus: | | | | | | |
| Sloughing | | .000 | | | | |
| Form retention | | | | | −.303 | −.559 |
| Crispness | +.727 | | | | | |

** Significant at the 1-percent point of F (variance ratio).
* Significant at the 5-percent point of F (variance ratio).

## SUMMARY

A study of the palatability of early potatoes of Irish Cobbler, Sebago, Triumph, and White Rose varieties was made by determining their suitability for boiling, mashing, baking, french frying, and use in salad. Chemical analyses for moisture and reducing sugar were made. Specific gravity of all sample lots was taken by means of the salt-density method.

Modal specific-gravity classes of Irish Cobbler, Sebago, Triumph, and White Rose varieties used in this study ranged from 1.06 to 1.08. Cooking samples for boiled, mashed, baked, french-fried, and salad potatoes were selected from the modal specific-gravity class of each sample lot for three replicate cooking tests. A palatability panel of seven trained judges scored the cooked products. Raw stock of all lots was analyzed for dry matter and reducing sugar.

Palatability scores showed that slight sloughing of the cortical layer occurred in all samples of boiled potatoes. No significant differences in dryness and mealiness were found among samples when potatoes were boiled and baked. When potatoes were mashed, however, Sebago and Irish Cobbler samples scored highest in both these characteristics, the differences being significant. Dryness was positively correlated with mealiness in boiled and mashed samples. Considerable variation was found in color of the cooked potatoes. In boiled and mashed samples, Triumph samples scored higher for color than did the others. Color scores for the mashed product were frequently higher than those for boiled and baked samples. Significant differences were found among samples for flavor of boiled, mashed, and baked potatoes. The Sebago sample grown in Alabama scored highest for flavor in boiled, mashed, and baked samples. In general, all samples were more desirable for mashing and boiling than for baking. Sebago and Irish Cobbler samples particularly gave good-quality mashed potatoes. All samples were satisfactory for boiling although when baked they were more moist and soggy than is desirable.

Judges' scores for potatoes prepared for use in salad were lower in all characteristics than scores for the same samples when boiled, mashed, or baked. No significant differences among samples were found. In contrast to boiled, mashed, and baked potatoes, high-quality salad potatoes need to be only moderately dry and mealy. In actual use in potato salad both color and flavor of potatoes are modified by added ingredients. Based upon these standards, all of these samples of early potatoes were found satisfactory for use in salad.

None of the early potatoes in this study were found to be highly desirable for french frying. Sebago and Irish Cobbler scored higher than the other samples for color, crispness, and flavor. Value for reducing sugars of the raw samples varied from 0.064 to 0.505 percent (fresh-weight basis) and were negatively correlated with palatability scores for color, crispness, and flavor of french fries. A positive correlation was found between specific gravity of the tubers and dry-matter content.

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